Fermilab

Directorate

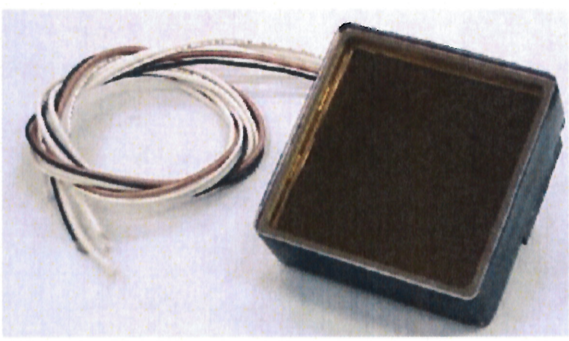
TECHNICAL SCOPE OF WORK

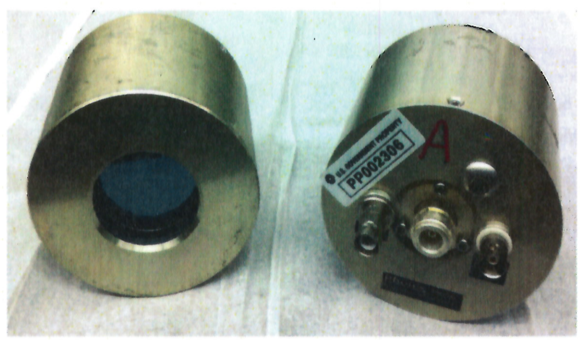
FOR THE 2015 - 2018 FERMILAB TEST BEAM FACILITY PROGRAM

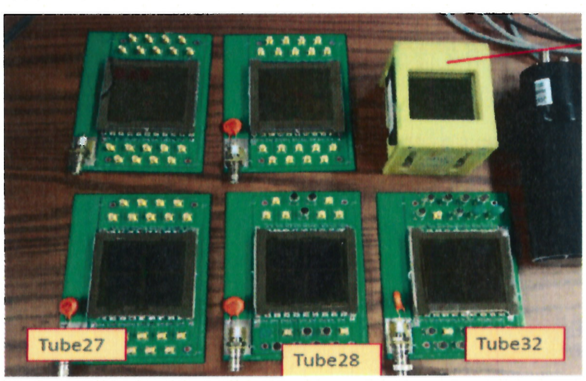
T-1065

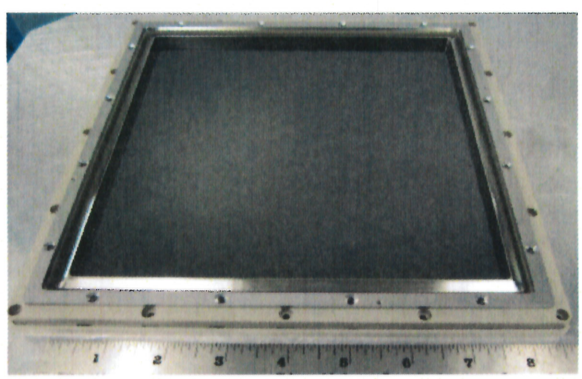
Secondary Emitters Study

March 6, 2015









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INTRODUCTION

This is a technical scope of work (TSW) between the Fermi National Accelerator Laboratory (Fermilab), California Institute of Technology and Argonne National Laboratory who have committed to participate in beam tests to be carried out during the 2015-2018 Fermilab Test Beam Facility program.

The TSW is intended primarily for the purpose of recording expectations for budget estimates and work allocations for Fermilab, the funding agencies and the participating institutions. It reflects an arrangement that currently is satisfactory to the parties; however, it is recognized and anticipated that changing circumstances of the evolving research program will necessitate revisions. The parties agree to modify this scope of work to reflect such required adjustments. Actual contractual obligations will be set forth in separate documents.

This TSW fulfills Article 1 (facilities and scope of work) of the User Agreements signed (or still to be signed) by an authorized representative of each institution collaborating on this experiment.

Description of Detector and Tests:

One possibility to make a fast and radiation resistant shower maximum (SM) detector or preshower detector is to use a secondary emitter (SE) as an active element. This method was proposed in 1990 [1]. Micro channel plates (MCP) were used as SE in the SM. The attractive properties of such SM are: 1) a two-dimensional map of energy at the SE location; 2) timing information at few tens of picosecond level, also as transverse shower size and 3) possible separation of electromagnetic and hadronic energy based on the differences of the shower size and timing.

An electron-multiplier-based sampling calorimeter requires thin planar detectors at an affordable cost. Large-area photo detectors based on ALD-functionalized 20-cm-square borosilicate glass capillary micro-channel plates (MCPs), currently being developed by the LAPPD Collaboration [2], are candidates for the active elements.

The first results of the new shower maximum detector with the micro channel plate photomultiplier (MCP-PMT) as active elements are described in the references [3]. The current proposal is the next natural step in this direction.

The experimenters propose using large-area MCPs assembled without the usual bialkali photocathodes as the active element in sampling calorimeters, as described in Ref. [2]. LAPPD modules without photocathodes can be economically assembled in a glove box and then pumped and sealed using the process to construct photomultipliers, bypassing the slow and expensive vacuum-transfer process required by bialkali photocathodes.

The first use of electron multipliers, in this case MCPs (Fig. 1, left) as an active element in multi-layer sampling calorimeters is described in Ref. [1]. A chevron of two MCPs in vacuum, was located behind a tungsten plate on which 5 GeV and 26 GeV electrons were incident (Fig. 1, right). The amplitude of the MCP signal (Fig. 2) as a function of the tungsten thickness was measured. The primary electrons produce a shower of secondary particles, including positron-electron pairs and gammas; the response of the MCPs (Fig. 2, left) is proportional to the number of particles in the shower, which is dependent on the initial particle energy. The MCP signal shape is presented in the Fig. 2, right). The FWHM of the signal is 1 ns.

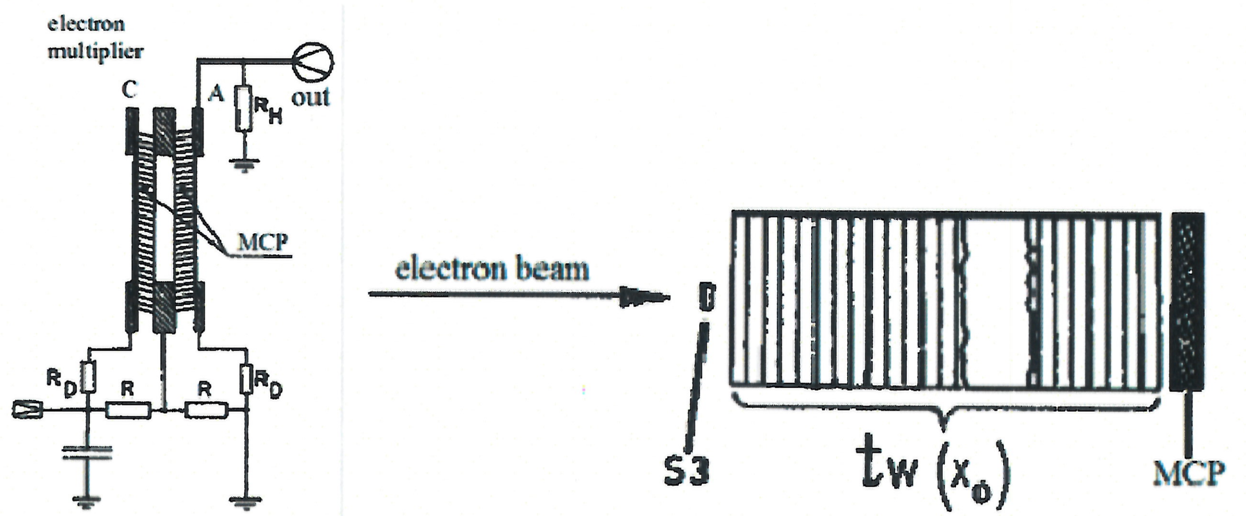


Fig. 1. The micro channel plate (MCP) schematics, left; and test beam setup, right. S3 - scintillation counter, tungsten thickness tw(X0), MCP – micro channel plate.

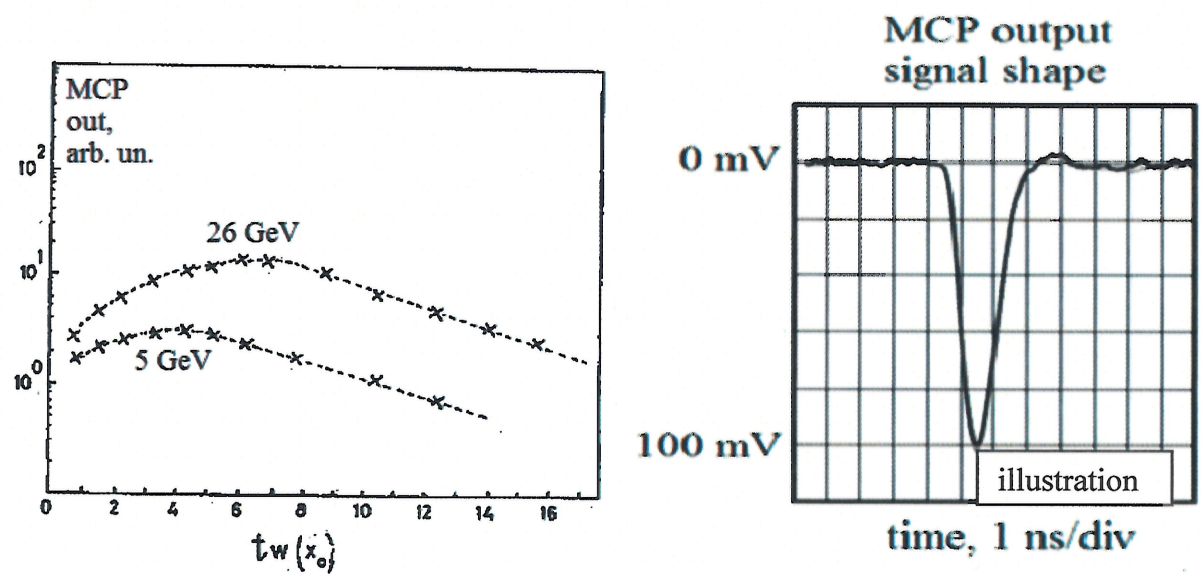


Fig. 2. The amplitude of the MCP signal as a function of the tungsten thickness tw(X_0), left; and MCP signal shape (for illustration), right.

The experimenters propose to investigate the possibility of producing a SM with W or Pb absorber plates with SE (MCP, venetian blinds or wire dynodes). Preliminary studies will be performed with a test beam at FTBF. If the results are promising the experimenters would like to construct and test a full-size SM module large enough to contain high-energy showers, although this will require investment in additional chips, boards, and person-power.

I. Personnel and Institutions:

Co-spokespersons and lead experimenters in charge of beam tests: Artur Apresyan, Caltech and Anatoly Ronzhin, Fermilab.

Fermilab Experiment Liaison Officer: Aria Soha

The group members at present are:

	Institution	Country	User	Rank/Position	Other Commitments
1.1	Argonne lab	USA	Marcel Demarteau	Scientist	ANL
			Robert Wagner	Physicist	ANL
			Jingbo Wang	Post doc	CMS
1.2	Fermilab	USA	Anatoly Ronzhin	Physicist	CMS
			Erik Ramberg	Scientist	CDMS
			Sergey Los	Engineer	CMS
1.3	Caltech	USA	Maria Spiropulu	Professor	CMS
			Artur Apresyan	Scientist	CMS
			Si Xie	Fellow	CMS
1.4	University Of Chicago	USA	Heejong Kim	Postdoc	CMS

II. EXPERIMENTAL AREA, BEAMS AND SCHEDULE CONSIDERATIONS:

2.1 LOCATION

2.1.1 The beam tests will take place in location MT6.2

2.2 BEAM

2.2.1 BEAM TYPES AND INTENSITIES

Energy of beam in GeV: 120 – protons; 2, 4, 8, 16, 32 – electrons.
Particles: protons, electrons.
Intensity: 10k – 100k particles/ 4 sec spill
Beam spot size: about 10cm^2

2.2.2 BEAM SHARING

Thin silicon telescope or gas detectors upstream of the detector is OK.

The radiation length of all the material intended to be in the beam is 27 rad. lengths as maximum.

2.3 EXPERIMENTAL CONDITIONS

2.3.1 AREA INFRASTRUCTURE

The main part of the equipment is located inside of a dark box with dimensions of 38"x22"x11". The weight is about 20-30 lb. Only a single secondary emission layer is placed outside the box for the test. The layer is located on X-Y moving stage. A standard rack with electronics will be located next to the box. The weight of the layer placed on the X-Y support with vessel is ~10 lb as maximum. The expected range of motion of the table is about 2" in X and in Y direction.

The experimenters request the use of the upstream Cherenkov counters, time of flight system for particles ID, set of scintillation counters of different size (sensitive area 1x1mm^2, 2x2mm^2, 3x3mm^2), and proportional chambers for tracking.

No gas is used in the experiment.

2.3.2 ELECTRONICS AND COMPUTING NEEDS

The experiment will digital samplers (DRS4 readout) developed by UC.

See Appendix II for PREP electronics requested.

The experimenters plan to bring a computer which should to be connected to the Fermilab Network.

2.3.3 DESCRIPTION OF TESTS

The experimenters will need access to the detector ~3-7 times per shift to change sets of secondary emitters for every beam type. This means that few sets of beam type preferable during the shift. The shift duration is about 8-12 hours (10am – 10pm are OK). Daytime hours are preferred for staffing reasons. Overnight shifts are possible if working in parallel with another experiment. It's expected to take ~1 working day to install equipment at the beam line before ORC inspection.

2.4 SCHEDULE

The length of each beam test is expected to be 1-2 weeks. With 3 beam test times during a 1 year period. The total duration of the experiment is about 3 years.

Experimental Planning Milestones

The first milestone could be the year 2015 to estimate possible budget for the detector construction and test. Data taking is expected by March of 2015. The particular time is bounded by prototype detector readiness and the need to present these performance results to the DOE as part of the project approval process.

III. RESPONSIBILITIES BY INSTITUTION – NON FERMILAB

3.1 ARGONNE

- The primary ANL responsibility will be production of the secondary emission layers (MCP, 6cmx6cm).
- Giga-sample waveform sampling electronics, for the SM readout.
- Shifts and data analysis.

3.2 CALTECH

- Develop signals waveform processing algorithms to get best timing.
- Develop simulation programs for electromagnetic showers with special attention to the low energy component (1-10 KeV) of a secondary shower's particles.
- Shifts and data analysis.

IV. RESPONSIBILITIES BY INSTITUTION – FERMILAB

4.1 FERMILAB ACCELERATOR DIVISION:

4.1.1 Use of MTest beamline as outlined in Section II. [0.25 FTE/week]
4.1.2 Maintenance of all existing standard beam line elements (SWICs, loss monitors, etc) instrumentation, controls, clock distribution, and power supplies.
4.1.3 Scalers and beam counter readouts will be made available via ACNET in the MTest control room.
4.1.4 Reasonable access to the equipment in the MTest beamline.
4.1.5 Connection to ACNET console and remote logging should be made available.
4.1.6 The test beam energy and beam line elements will be under the control of the AD Operations Department Main Control Room (MCR). [0.25 FTE/week]
4.1.7 Position and focus of the beam on the experimental devices under test will be under control of MCR. Control of secondary devices that provide these functions may be delegated to the experimenters as long as it does not violate the Shielding Assessment or provide potential for significant equipment damage.
4.1.8 The integrated effect of running this and other SY120 beams will not reduce the neutrino flux by more than an amount set by the office of Program Planning, with the details of scheduling to be worked out between the experimenters and the Office of Program Planning.

4.2 FERMILAB PARTICLE PHYSICS DIVISION:

4.2.1 The test-beam efforts in this TSW will make use of the Fermilab Test Beam Facility. Requirements for the beam and user facilities are given in Section II. The Fermilab PPD DDO Test Beam Group will be responsible for coordinating overall activities in the MTest beam-line, including use of the user beam-line controls, readout of the beam-line detectors, and FTBF computers. [6.5 FTE/week]
4.2.2 FTBF will provide and maintain motion tables for the dark box placement, The expected range of motion of the table is about 7" in X and 3" in Y direction.
4.2.3 Tracking or trigger systems as specified in Section II.
4.2.4 Conduct a NEPA review of the experiment.
4.2.5 Provide day-to-day ESH&Q support/oversight/review of work and documents as necessary.
4.2.6 Provide safety training as necessary, with assistance from the ESH&Q Section.
4.2.7 Update/create ITNA's for users on the experiment.
4.2.8 Initiate the ESH&Q Operational Readiness Clearance Review and any other required safety reviews.

4.3 FERMILAB SCIENTIFIC COMPUTING DIVISION

4.3.1 Internet access should be continuously available in the MTest control room.
4.3.2 One computer (brought by experimenters) should to be connected to the Fermilab Network.
4.3.3 See Appendix II for PREP electronics requested.

4.4 Fermilab ESH&Q Section

4.4.1 Assistance with safety reviews.

4.4.2 Provide safety training, with assistance from PPD, as necessary for experimenters. [0.2 FTE]

V. Summary of Costs

Source of Funds [$K]	Materials & Services	Labor (person-weeks)
Accelerator Division	0	0.5
Particle Physics Division	0.0	6.5
Scientific Computing Division	0	0
ESH&Q Section	0	0.2
Totals Fermilab	$0.0K	7.2
Totals Non-Fermilab	$10k	7

VI. General Considerations

6.1 The responsibilities of the co-spokespersons and the procedures to be followed by experimenters are found in the Fermilab publication "Procedures for Researchers": (http://www.fnal.gov/directorate/PFX/PFX.pdf). The co-spokespersons agree to those responsibilities and to ensure that the experimenters all follow the described procedures.

6.2 To carry out the experiment a number of Environmental, Safety and Health (ESH&Q) reviews are necessary. This includes creating an Operational Readiness Clearance document in conjunction with the standing Particle Physics Division committee. The co-spokespersons will follow those procedures in a timely manner, as well as any other requirements put forth by the Division's Safety Officer.

6.3 The co-spokespersons will ensure at least one person is present at the Fermilab Test Beam Facility whenever beam is delivered and that this person is knowledgeable about the experiment's hazards.

6.4 All regulations concerning radioactive sources will be followed. No radioactive sources will be carried onto the site or moved without the approval of the Fermilab ESH&Q section.

6.5 All items in the Fermilab Policy on Computing will be followed by the experimenters. (http://computing.fnal.gov/cd/policy/cpolicy.pdf).

6.6 The co-spokespersons will undertake to ensure that no PREP or computing equipment be transferred from the experiment to another use except with the approval of and through the mechanism provided by the Scientific Computing Division management. The Spokespersons also undertake to ensure no modifications of PREP equipment take place without the knowledge and written consent of the Computing Sector management.

6.7 The experimenters will be responsible for maintaining both the electronics and the computing hardware supplied by them for the experiment. Fermilab will be responsible for repair and maintenance of the Fermilab-supplied electronics listed in Appendix II. Any items for which the experiment requests that Fermilab performs maintenance and repair should appear explicitly in this agreement.

6.8 An experimenter will be available to report on the test beam effort at a Fermilab All Experimenters' Meeting.

6.9 The co-spokespersons are the official contact and are responsible for forwarding all pertinent information to the rest of the group, arranging for their training, and requesting ORC or any other necessary approvals for the experiment to run.

6.10 The co-spokespersons are responsible for ensuring the appropriate people (which might be everyone on the experiment) sign up for the test beam emailing list.

6.11 The spokespersons, or designee, will generate a one-page summary of the experiment's use of the Test Beam facility during the fiscal year, to be included in the annual Test Beam Report Fermilab submits to the DOE.

At the completion of the experiment:

6.12 The co-spokespersons are responsible for the return of all PREP equipment, computing equipment and non-PREP data acquisition electronics. If the return is not completed after a period of one year after the end of running the Spokespersons will be required to furnish, in writing, an explanation for any non-return.

6.13 The experimenters agree to remove their experimental equipment as the Laboratory requests them to. They agree to remove it expeditiously and in compliance with all ESH&Q requirements, including those related to transportation. All the expenses and personnel for the removal will be borne by the experimenters unless removal requires facilities and personnel not able to be supplied by them, such a rigging, crane operation, etc.

VII. BIBLIOGRAPHY

1. A. A. Derevshchikov, V. Yu. Khodyrev, V.I. Kryshkin, V.E. Rakhmatov, A. I. Ronzhin, "On possibility to make a new type of calorimeter: radiation resistant and fast". Preprint IFVE 90-99, Protvino, Russia, 1990.
2. B. Adams, A. Elagin, H. Frisch, R. Obaid, E. Oberla, A. Vostrikov, R. Wagner, M. Wetstein. "Measurements of the gain, time resolution, and special resolution of a 20x20 cm2 MCP based picosecond detector". Nuclear Instruments and Methods. A 732 (2013) 392-396.
3. A. Ronzhin, S. Los, E. Ramberg, M. Spiropulu, A. Apresyan, S. Xie, H. Kim, A. Zatserklyaniy "Development of a new fast shower maximum detector based on micro channel plates photomultipliers (MCP-PMT) as an active element", submitted to NIM, NIMA-D-14-00186, 2014

SIGNATURES:

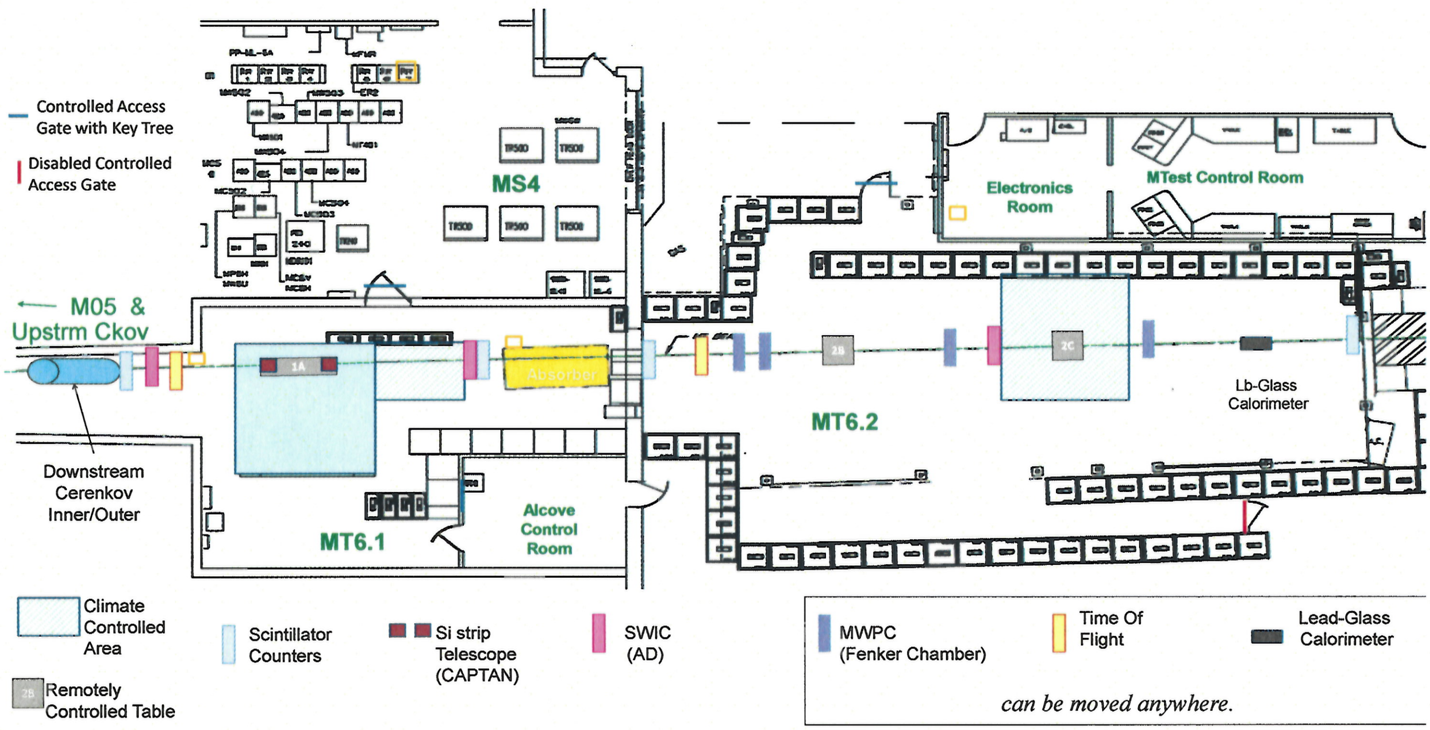
______________________________ 03 / 06 / 2015
Artur Apresyan, Experiment Co-spokesperson

Anatoly Ronzhin ______________________________ 03 / 06 / 2015
Anatoly Ronzhin, Experiment Co-spokesperson

APPENDIX I: MT6 AREA LAYOUT

The equipment is expected to be in the MT6.2B Area on the moving table with two MWPCs in front of it.

MTEST AREAS



APPENDIX II: EQUIPMENT NEEDS

Equipment Pool and PPD items needed for Fermilab test beam, on the first day of setup.

PREP EQUIPMENT POOL:

Quantity	Description
1	Fluke HV PS
1	Cow

PPD FTBF:

Quantity	Description
2	MWPC Stations
1	Time of Flight System
7	Scintillator counters

APPENDIX III: - HAZARD IDENTIFICATION CHECKLIST

Items for which there is anticipated need have been checked.
See ORC Guidelines for detailed descriptions of categories.

Flammables (Gases or Liquids)		**Gasses**		**Hazardous Chemicals**		**Other Hazardous /Toxic Materials**
Type:		Type:			Cyanide plating materials	List hazardous/toxic materials planned for use in a beam line or an experimental enclosure:
Flow rate:		Flow rate:			Hydrofluoric Acid	
Capacity:		Capacity:			Methane	
Radioactive Sources		**Target Materials**			photographic developers	
	Permanent Installation		Beryllium (Be)		PolyChlorinatedBiphenyls	
	Temporary Use		Lithium (Li)		Scintillation Oil	
Type:			Mercury (Hg)		TEA	
Strength:			Lead (Pb)		TMAE	
Lasers		X	Tungsten (W)		Other: Activated Water?	
	Permanent installation		Uranium (U)			
	Temporary installation		Other:	**Nuclear Materials**		
	Calibration	**Electrical Equipment**		Name:		
	Alignment		Cryo/Electrical devices	Weight:		
Type:			Capacitor Banks	**Mechanical Structures**		
Wattage:			High Voltage (50V)		Lifting Devices	
MFR Class:			Exposed Equipment over 50 V	X	Motion Controllers	
			Non-commercial/Non-PREP		Scaffolding/ Elevated Platforms	
			Modified Commercial/PREP		Other:	
Vacuum Vessels		**Pressure Vessels**		**Cryogenics**		
Inside Diameter:		Inside Diameter:			Beam line magnets	
Operating Pressure:		Operating Pressure:			Analysis magnets	
Window Material:		Window Material:			Target	
Window Thickness:		Window Thickness:			Bubble chamber	

The following people have read this TSW:

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Sergei Nagaitsev, Accelerator Division, Fermilab

Martha E. Michels ________________________________ 3 / 6 / 2015
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